学 位 論 文 内 容 の 要 旨

博士（環境科学）　　氏 名 Islam Mohammad Anowarul

学 位 論 文 題 名

Statistical analysis on the effect of precipitation on the variability of extreme sea levels along the coast of Bangladesh

（バングラデシュ沿岸域における極端な高水位の変動をもたらす降水の効果に関する統計解析）

The global mean sea level rise under climate change is an alarming issue to the sustainability of the coastal communities. The sea level rise enhances the vulnerability to cope with associated hazard for developing nations. Bangladesh is highly vulnerable to the adverse impacts of extreme sea levels (ESLs) because of its geographical location with low-lying deltaic coast and the inadequate infrastructure with high population exposure. In addition, as most downstream area of large Ganges-Brahmaputra-Meghna (GBM) River and Sangu-Matamuhuri River near Arakan hilly area, the central and eastern coast of Bangladesh receives abundant precipitated-water from the upstream, respectively. The resultant increase in precipitated-water discharge from the upstream areas may enhance the ESL-induced flood risk along the coast. The ESL arises from the combined interaction of different meteorological forcings. The effects of meteorological forcings like atmospheric pressure, storm-induced surges, and wind-induced waves to ESL have been investigated intensively. However, the influence of terrestrial precipitation to the ESL along the Bangladesh coast remains unknown despite the region is known as the highest precipitation-prone area in the world. In this study, the influence of precipitation on ESL was investigated for Cox's Bazar, Charchanga, and Khepupara stations, which represent three different geographical areas on the eastern, central, and western coast, respectively.

The ESL events were obtained from the available daily sea level data at Cox's Bazar (1983–2006), Charchanga (1980–2000), and Khepupara (1987–2000). To remove the seasonality in observed sea level, the anomalous sea level relative to the 91 days running mean was used. The 99th percentile values of daily sea level anomaly (SLA) were used as a threshold for the identification of ESL events. After excluding the consecutive days before and after the peak sea level, in total 35, 30, and 18 independent ESL events were selected for Cox's Bazar, Charchanga, and Khepupara, respectively. The variations in daily SLA during seven days prior to the ESL day were predicted by multivariate linear regression (MLR) using four meteorological variables of precipitation, sea level pressure, zonal, and meridional wind. The basin average accumulated precipitation over five days was used to account the delay effect in precipitation runoff. The daily sea level pressure and wind were averaged over the Bay of Bengal. The spatiotemporal variations of the meteorological variables during ESL events showed the presence of low pressure system and associated cyclonic circulation over the coast and high precipitation especially

for Cox's Bazar area. It is revealed that the prediction of ESL height considering precipitation effects outperformed predictions without precipitation. To understand the causality of the precipitation effect, each term of the MLR was investigated. The gradual increase in sea level towards the day of extreme was mainly brought by the contribution of precipitation term rather than the other atmospheric forcings for Cox's Bazar. In contrast, the influence of precipitation term is relatively small for Charchanga and Khepupara. Therefore, the benefit of incorporating precipitation effect is greater at Cox's Bazar than Charchanga and Khepupara. This is consistent with the hilly landscape of Sangu-Matamuhuri River basin near Cox's Bazar because a clear response of sea level to river runoff is expected there. The SLP and winds are the main drivers for ESL height during many ESL events at Charchanga and Khepupara. The analysis revealed that the sensitivity of ESL height to precipitation was high during the monsoon season. At Cox's Bazar, the effect of precipitation tended to be strong during June and July. This is presumably because high frequency of strong daily precipitation during the monsoon season. In contrast, at Charchanga and Khepupara the ESL events with high effect of precipitation was occurred during post-monsoon season.

The MLR created for each event had led to very high predictability. This is partly because the degree of freedom for predictand is closer to the number of explanatory variables. Therefore, a new MLR was built using all ESL days including their prior six days at each station to validate the robustness of precipitation's effect on ESL revealed by the MLR created for each event. In total 245, 210, and 126 sample days were used for Cox's Bazar, Charchanga, and Khepupara, respectively. The result again showed that the daily sea level is better predicted with incorporation of precipitation based on the evaluation using adjusted R^2. The MLR represent the large contribution of precipitation term to the ESL height at Cox's Bazar than Charchanga and Khepupara, as it was confirmed by the MLR for each event.

The intensive monitoring of the site-dependent key meteorological factors and the incorporation of their effects to prediction model are essential to improve the prediction of ESL. These efforts will be mandatory to develop early warning system of the ESL event for reducing the risk of the hazards and for better coastal management. In the context of changing climate, climate models projected the increase in the intensity of heavy precipitation, high winds, and strong cyclone events in future due to anthropogenic greenhouse gas emissions. Therefore, future changes in ESL events should be discussed based on the examination of the future changes in key meteorological forcings, which will help reduce the vulnerability of the coastal community and ensure coastal sustainability.